UDOT
CONNECTING COMMUNITIES

GIS Strategic Plan

July 2008

URS

List of Acronyms

2D	Two-Dimensional
3D	Three-Dimensional
AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
AGRC	Automated Geographic Reference Center
ATMS	Automated Management Traffic System
BLM	Bureau of Land Management
CADD	Computer-Aided Design and Drafting
DOT	Department of Transportation
DTM	Digital Terrain Model
DEM	Digital Elevation Model
DTS	Department of Technology Services
EIS	Environmental Impact Study
ePM	Electronic Program Management
ESRI	Environmental Systems Research Institute
ETS	Engineering Technology Systems
FEMA	Federal Emergency Management Agency
FHWA	Federal Highways Administration
FTE	Full Time Employee (Equivalent)
GIS	Geographic Information Systems
GPS	Global Positioning System
GTEAS	Geographic Transportation Environmental Assessment System
HEC-RAS	Hydrologic Engineering Center River Analysis System
ISS	Information Support Services
LRS	Location Reference Standard
MFI	Maintenance Feature Inventory
MMQA	Maintenance Management Quality Assurance Program
NAD	North American Datum
NEPA	National Environmental Policy Act
OMS	Operations Management System
PC	Personal Computer
PDBS	Project Development Business System
PDF	Portable Document Format
PLSS	Public Land Survey System
QC/QA	Quality Control/Quality Assurance
RDBMS	Relational Database Management System
RFP	Request for Proposal
SPP	Systems Planning and Programming
STIP	Statewide Transportation Improvement Program
T&E	Threatened and Endangered
UDOT	Utah Department of Transportation
UTA	Utah Transit Authority
UTM	Universal Transverse Mercator

Executive Summary

Introduction

Proactively managing the State transportation system requires UDOT to have a strong focus on information management. There are large amounts of data generated and managed by groups, divisions, and regions within UDOT (including vendors and consultants). The accuracy, completeness, availability, and accessibility of these data are essential to UDOT staff performing business functions within the Department to make better informed decisions and maintain efficiency. Because the road network is an inherently spatial network (i.e., defined in geographic space), the use of Geographic Information Systems (GIS) seems like a natural fit to complement and enhance business data systems currently in place. The process towards successfully meeting UDOT's Final Four strategic goals can greatly benefit from the integration of GIS tools into the Department's information management processes.

In 2007 the Engineering Technology Systems (ETS) section at UDOT, in conjunction with the GIS Steering Committee, initiated the process of determining whether the coordinated use of GIS technology can benefit and potentially improve the Department's day-to-day business processes. This GIS Strategic Plan describes the results of a "10,000 ft level" look at GIS at the Department, focusing on the big picture, rather than specific details, metrics, and figures. It is expected that the recommendations put forth in this plan will lead to specific implementation planning efforts outlining these details.

To gather input on GIS at the Department a GIS Visioning Workshop was conducted on January 31, 2008, which was attended by 58 UDOT staff and three representatives from the Automated Geographic Reference Center (AGRC). The AGRC, which is part of the State of Utah Division of Technology Services (DTS), is focused on optimizing statewide GIS data management. A report was prepared summarizing the information gathered at the workshop, which is included as an Appendix to the GIS Strategic Plan.

Vision Statement

The following vision statement was developed to aid in a successful GIS strategy at UDOT:

"UDOT's integrated GIS strategy strives to optimize the access, viewing, and analysis capabilities of accurate, up-to-date Department business data in a flexible, easy-to-use spatial (map based) environment to help achieve and improve UDOT's business objectives, while leveraging existing technology investments".

GIS

A Geographic Information System (GIS) provides a common framework for viewing and analyzing data from many different (business) data systems through the use of a map-based interface, adding a geographic component to traditional tabular database analyses. There are many software packages available that provide GIS capabilities and UDOT has invested in several of them. These include traditional desktop GIS applications such as ESRI's ArcGIS suite, CADD-based packages such as Microstation, mobile GPS-based applications, and online applications such as Google Earth that provide GIS functionality without any software requirements on the user's end. Additionally, UDOT has been investing significant funds in applications and/or initiatives that either have a significant GIS component or use GIS concepts in their functionality. Examples include OMS, GTEAS, SPP, LRS Online, and the online Utah Bridges Portal. There currently are many types of GIS users at UDOT, ranging from application developers with a computer science background, geographers with a direct GIS background, engineers and environmental professionals dealing with specific data, to casual users who need answers without having to do comprehensive data management and analysis.

Benefits

Uniform access to spatial data linked to many databases within the Department, and from outside sources provides several direct and indirect business benefits. These include:

- Access to uniform data across the Department leading to a consistent "base" on which decisions are being made;
- Quicker access to better data leading to more efficiency and productivity, and less redundancy;
- Quick access to integrated information, which is critical in emergency situations;
- Making mobile GIS tools available to field staff improving the accuracy and efficiency of the data collection process;
- Facilitating the (graphic) capture of important institutional knowledge directly linked to the relevant asset;
- Leveraging datasets that UDOT already paid for allowing for future project savings and better informed planning;
- Integrating business data using GIS, introducing a map-based QC/QA process, reducing data errors;
- Improved integration of outside GIS data, which becomes easier with an integrated GIS structure.

UDOT's LRS and GIS

UDOT's Location Reference Standard (LRS) defines locations along the State road network based on mileage and reference posts. While the LRS is intuitive and structured, it can't capture all geographic information relevant to UDOT, such as features not located on or related to the road network itself (rail roads, floodplains, municipality boundaries, etc.). Additionally, the LRS does not provide the user with an interface on which to visually review UDOT business data related to Department assets. This is where GIS information, referenced using geographic coordinates (such as latitude/longitude, northing/easting, etc.) and accessible using a map-based interface, provides complementary functionality to traditional LRS definitions. Locations along the road network captured in the LRS can be converted to geographic (GIS) coordinates and vice versa. Both systems are fully compatible and leveraging the power of both types of referencing methods will provide the biggest benefit to the Department.

Challenges

While the LRS has been adopted as a standard for UDOT in managing and referencing the State road network, there is currently no clearly defined direction for dealing with GIS information at the Department. UDOT's ETS section includes GIS staff that provide Department-wide GIS support. In addition, several other groups, divisions, and regions have staff proficient in and assigned to GIS data management. However, GIS data are residing throughout the Department, located on both network servers and individual work stations. These data are currently not tracked systematically and are only minimally standardized, making it near impossible to ensure that the correct data is being used for the right purpose. Other (related) issues that were identified regarding currently used GIS data include inconsistencies in geographic coverage, resolution, and reference systems and inadequate documentation (metadata) describing each dataset's source, accuracy, and intended use. In addition many of the application development efforts that involve GIS are not (or inadequately) coordinated, likely resulting in duplicate data management related efforts and inefficient use of available time and staff.

Goals and Recommendations

Using gathered information and the feedback from UDOT staff, the following nine goals with associated recommendations were developed. These have been prioritized as follows with input from the GIS Steering Committee:

Goal 1: Establish an accurate set of basic spatial (GIS) information (a "master" dataset), consisting of accurate and standardized geographic definitions of UDOT's key assets such as the road network layout, bridge locations, etc.

Recommendations: Determine what UDOT and non-UDOT GIS information needs to be included in the master GIS dataset through carefully analyzing the potential uses of GIS datasets as they relate to improving UDOT's business processes. Subsequently a GIS data management plan needs to be developed to ensure that the GIS location data is managed in the division that manages the associated assets and that the appropriate information for its intended use is documented.

Goal 2: Establish appropriate data security; QC/QA; and documentation protocol.

Recommendations: Determine what data should be available to the public and what data are for internal use only. Evaluate data editing and sharing privileges for internal staff and develop a plan for capturing data from proprietary databases such as Pontis. Finally, the appropriate QC/QA procedures and data documentation standards need to be established for all relevant data.

Goal 3: Optimize the integration of existing UDOT business data systems (such as ePM, OMS, PDBS, Pontis, etc.) with GIS tools.

Recommendations: Optimize relationships between existing business data systems based on common assets to allow for data to be available to the GIS user in an integrated, common framework using a spatial data engine and available Oracle tools. Additionally, standards and protocol need to be developed to ensure that information is kept accurate and up-to-date and that the appropriate LRS/GIS/Oracle integration and conversions are implemented to preserve data integrity.

Goal 4: Optimize the use of existing business GIS applications and datasets.

Recommendations: Conduct a detailed evaluation of existing GIS applications to determine whether certain applications developed for a specific purpose or division can serve another purpose / division with some minor adjustments, thereby saving funds that otherwise might have gone to a brand new application or project. Additionally, existing specialty software should be evaluated as well as the applicability of Google and other online applications. Finally, GIS data that are owned and paid for by UDOT on past projects should be captured, inventoried, and leveraged for future projects and planning efforts. This will likely limit duplicate data collection efforts and improve overall efficiency**.**

Goal 5: Optimize field data collection methods.

Recommendations: Inventory current data collection methods and establish a formal data collection protocol (including standards and requirements), detailing the preferred method to capture specific location data in the field (LRS, GIS/GPS). Train field staff on the use of (new) data collection techniques if appropriate and/or required.

Goal 6: Optimize UDOT's relationship with the AGRC.

Recommendations: Allow the AGRC to provide appropriate UDOT datasets describing the State's transportation network and its assets to the public. In addition, evaluate where it might make sense to partner with the AGRC on strategic initiatives, data collection and storage, and application development.

Goal 7: Establish a staffing strategy.

Recommendations: This strategy should be targeted towards improving coordination among GIS staff throughout the Department on GIS data management and application development; optimizing the role of a GIS Committee; encouraging integration of UDOT DTS Staff in GIS initiatives across the Department; and implementing a plan for providing Department-wide GIS technical support.

Goal 8: Develop an online portal providing UDOT staff access to business data through GIS.

Recommendations: Determine what type of web service is appropriate, either in collaboration with the AGRC and/or through expanding UDOT's current GIS site (www.gis.udot.utah.gov). Develop viewing, analysis, and downloading functionality, and implement appropriate security protocol. Evaluate what (master) GIS datasets and enterprise business data systems should be available for access.

Goal 9: Establish an outreach strategy.

Recommendations: Develop an outreach plan focused on making Department staff aware of how GIS can help them in their jobs; what data are available; the tools available for GIS display and analysis; and who to go to for help. This could be accomplished through a series of workshops and presentations at different divisions, groups, and regions.

Next Steps

For steps to be taken towards an optimized, integrated GIS Strategy, it is vital to secure upper management support for the goals and recommendations presented in this plan. When the support for this plan is ensured and it is agreed upon that investing in and optimizing GIS at UDOT is a worthwhile effort from a business perspective, the necessary implementation and technology plans can be developed detailing funding and staffing needs. Related to these plans it is important to officially sanction a Department GIS committee and validate its mission and responsibilities.

Section 1 - Introduction

As the population of Utah continues to grow, the demands on our transportation network are increasing accordingly. The Utah Department of Transportation is addressing the associated challenges through its strategic goals, known as the “Final Four”:

1. Take Care of What We Have
2. Make The System Work Better
3. Improve Safety
4. Increase Capacity

Proactively managing the State transportation system requires a strong focus on information management. There are large amounts of data generated and managed by groups, divisions, and regions within UDOT (including vendors and consultants). The accuracy, completeness, availability, and accessibility of these data are essential to UDOT staff performing day-to-day business functions within the Department to make better informed decisions and maintain efficiency. Because the road network is an inherently spatial network (i.e., defined in geographic space), the use of Geographic Information Systems (GIS) seems like a natural fit to complement and enhance business data systems currently in place. The concept of GIS revolves around linking business data directly to geographic features. This enables the viewing and analysis of these business data in a spatial (map-based) environment by people across the organization, keeping the institutional knowledge with the asset rather than with specific staff or divisions within the organization. The process towards successfully meeting UDOT’s Final Four strategic goals can greatly benefit from the integration of GIS tools into the Department’s information management processes.

This report is structured as follows: Section 2 describes the objectives and focus of this Strategic Plan after which a general introduction to GIS is provided in Section 3. Section 4 discusses the (business) reasons why UDOT should invest in GIS. The last two sections deal more specifically with the current status of GIS at UDOT. This includes the current status of GIS at the Department and associated challenges (Section 5) and goals and recommendations (Section 6).

Section 2 - Objectives and Focus of the GIS Strategic Plan

In 2007 the Engineering Technology Systems (ETS) section at UDOT, in conjunction with the GIS Steering Committee, initiated the process of establishing a clear direction and strategy for implementing and optimizing the use of GIS technology at the Department. The GIS Steering Committee is composed of representatives of several major divisions/groups at UDOT utilizing GIS technology as part of their work.

2.1 - Objectives

The concept of a GIS Strategic Plan for UDOT is not new. The Department has been striving to optimize the process of viewing and analyzing business data in a spatial (map based) environment since the mid-1990s. Strategic initiatives have included the 1995 GIS-T Implementation and Operation Plan; and the 1997 UDOT GIS Strategic Plan. In the 10+ years since this latest plan was written, there has been a significant evolution of GIS technology; available GIS data; (potential) applications; and number of end users. Additionally, this current effort has a slightly different focus than the original plan and is centered on the following objectives:

- Keeping the Strategic Plan at the “10,000 ft level,” focusing on strategic direction, assessments, and recommendations (as opposed to discussions on data formats, software packages, etc.);
- Leveraging current GIS initiatives and past and present Department investments involving GIS;
- Emphasizing the benefits of optimizing the current GIS structure, rather than proposing a brand new, high cost implementation of a new “system”; and
- Most importantly, evaluating whether the coordinated use of GIS technology can benefit and potentially improve the Department’s day-to-day business processes.

2.2 - Visioning Workshop

With these objectives in mind, a GIS Visioning Workshop was conducted to gather input on GIS at the Department, conduct interviews and meetings to obtain pertinent information from GIS users, and to write this Strategic Plan establishing a direction and framework for moving forward with GIS initiatives at the Department. In addition, a presentation will be conducted to UDOT upper management outlining the vision and recommendations presented in this plan, and to secure ongoing support for this initiative.

The Visioning Workshop was conducted on January 31, 2008, and was attended by 58 UDOT staff with URS Corporation facilitating the workshop. Three staff members from the Automated Geographic Reference Center (AGRC) were also included in the workshop to provide a broader perspective of GIS in Utah. The AGRC is a division of

DTS (Department of Technology Services) focused on the management and application of GIS data throughout Utah working with all relevant state and federal agencies as well as local government entities. The Visioning Workshop summary report is included as Appendix A to this report. Some of the conclusions of the Visioning Workshop are discussed in subsequent sections of this report.

2.3 - Vision Statement

The following vision statement was developed to aid in a successful GIS strategy at UDOT:

"UDOT's integrated GIS strategy strives to optimize the access, viewing, and analysis capabilities of accurate, up-to-date Department business data in a flexible, easy-to-use spatial (map based) environment to help achieve and improve UDOT's business objectives, while leveraging existing technology investments".

2.4 - Myths and Misconceptions

This sub section describes some of the main myths and misconceptions that exist about the (potential) role of GIS at the Department, based on input during the Visioning Workshop and conversations with UDOT staff. Subsequent sections of the report will touch on these items in more depth:

- Things are working fine as they are; why do we need GIS?
UDOT is already using GIS concepts and technology across the Department. There are numerous GIS software licenses currently being used in several divisions and each of the regions. Additionally, Autodesk and Bentley applications use GIS concepts and Google Earth is used widely as well. The issue is not whether the Department needs to start using GIS; it is how to optimize the existing use of GIS and the funds that UDOT has been spending on GIS related initiatives

- GIS is incompatible with and/or potentially hindering the engineering (CADD) processes at UDOT.
GIS as a concept does not involve engineering design, nor is GIS software designed for that purpose. While GIS might aid engineering analysis in many software packages and applications, its main concept revolves around linking business data to spatial features for display and analysis. The role of CADD packages (such as Microstation) at UDOT is for engineering design. These are two distinctly different purposes.

- GIS is incompatible with LRS and a firm choice needs to be made between the two when referencing data
UDOT's Location Reference Standard is based on Utah's road network, while most GIS data is based on geometries (shapes) in relation to geographic coordinates. Not only can corresponding location information in both systems be linked to the same business data, LRS location definitions can directly be converted to geographic information compatible with GIS software and vice versa. Both systems are fully compatible and

leveraging the power of both types of referencing methods will provide the biggest benefit to the Department.

- GIS implementation involves revamping UDOT's business data management structure and practices

UDOT's business data systems can be linked to geographic features such as bridges and roads in their current format. Most systems are designed and residing in Oracle, which is fully compatible with GIS data engines and interfaces.

Section 3 - Introduction to Geographic Information Systems

This section provides a general introduction to the concept of Geographic Information Systems as well as associated technologies and applications. Additionally some key GIS variables such as working environments, data types and formats, accuracy and quality variables, and types of users are discussed.

3.1 - The Concept of GIS

The concept of GIS is centered around viewing data and conducting analysis based on geographic locations. A simple, straightforward example would be the analysis of what land parcels are affected by a proposed road realignment. Using GIS tools on a map-based interface, the proposed alignment can be overlaid on a parcel layer. A click-of-a-button intersection algorithm built into the GIS software can highlight the affected parcels and export the associated ownership information to an excel spreadsheet, making this information instantly available to right-of-way, public involvement, and engineering staff. GIS provides a common framework for viewing and analyzing data from many different business data systems through the use of a single map-based interface. This adds a geographic component to traditional tabular database analyses and allows the user to view data relationships not obvious in tabular structures.

3.2 - Reference Systems

Locations displayed using GIS are traditionally referenced using **geographic coordinates** (such as latitude/longitude, northing/easting, etc.) referenced to a **datum** (the projection of (a portion of) the earth's globe onto a flat surface). This is referred to as a **coordinate system**. The most commonly used examples are UTM (Universal Transverse Mercator) or State Plane coordinates. State Plane is technically not a coordinate system itself, but can be referred to as such for the purpose of this discussion. The North American Datums of 1927 and 1983 (NAD 27 or NAD 83) are the most commonly used datums. In addition, UTM and State Plane have zones specific to portions of the country. Utah is located in UTM Zone 12 and there are three State Plane Zones (North, Central, South) in the State of Utah. Coordinates based on these systems are sometimes referred to as "real world" coordinates (i.e., they define a position on the earth). These coordinates don't provide enough accuracy to aid in for example roadway design. Design projects usually focus on a very small portion of the earth and require a very accurate depiction of location and elevation. This is commonly achieved through a professional survey with local survey control. However, these "local" coordinates can easily be converted to real world coordinates to allow for both sets of data to be available for concurrent display and analysis in a GIS environment.

3.3 - The Evolution of GIS Technology

When the concept of GIS analysis was first introduced in the 1980s, spatial analysis required a strong computer science and programming background as well as expensive hardware. The 1990s saw an evolution to more user friendly interfaces. At first, this came at the expense of comprehensive analysis tools. A good example of this is the first version of ArcView from Environmental Systems Research Institute (ESRI). While the evolution away from the traditional "command line" ArcInfo structure provided a more user friendly interface, this came at the expense of strong analysis functionality present in ArcInfo. Finally, in the 2000s, the evolution of GIS technology allowed GIS software to be both user-friendly and comprehensive in its technical capabilities. ESRI's ArcGIS suite, which combines both ArcView and ArcInfo, is a good example of this. It is, however, important to note that the evolution of servers and desktop computers, the associated memory and processing power, and a greater affordability for organizations such as UDOT to acquire this hardware, has made this evolution possible in the first place. In more recent years the evolution of GIS technology has included online applications serving geographic data. Companies such as Google are in the process of defining the future of managing and serving spatial data.

3.4 - GIS Software Packages

Currently, there are many software packages on the market that are specialized in providing GIS functionality. The industry leader in the United States is ESRI, based in Redlands, California. ESRI's suite of products (ArcGIS, ArcView, ArcInfo, ArcSDE, etc.) is the most commonly used GIS software suite throughout Utah both in the public and private sector. In addition, many third party applications have been developed that run on the ArcGIS platform or provide a great deal of interoperability with ESRI products. Examples include: FEMA's HAZUS disaster modeling software; the Army Corps of Engineers HEC-RAS hydraulic modeling software; and many other utility, engineering, and network models. However, ESRI is not the only option for a "standard" GIS package and there are also many specialized software packages available that provide stand-alone GIS and data management functionality, many of them focused on the business processes within the transportation industry.

Simply said, any software package that provides the user the functionality to link business data (attributes) to geographic features on a map-based interface for review and analysis can be considered GIS software. This includes the aforementioned traditional GIS software packages (such as ESRI ArcGIS, Intergraph Geomedia, MapInfo, etc.); open source applications with these functionalities (software that is distributed with its source code so that end user organizations and vendors can modify it for their own purposes); CADD packages with improved GIS functionality (such as AutoCad Map and Bentley's geospatial suite); specialized software applications targeted towards managing a specific asset (such as a utility or a road network); and online applications such as Google Earth. Google Earth is a prime example of how most of us are using GIS on a regular basis. Business data is built into the underlying application and users can link their own information to the map interface. Finally, even the spatial definitions that can be associated with data residing in an Oracle database (Oracle Spatial) can be considered providing GIS functionality (the ability to perform spatial analysis).

3.5 - GIS Environments

The three main environments that GIS can be used in are: desktop GIS, web-based GIS, and mobile GIS.

Desktop GIS refers to using GIS on a desktop or laptop computer with the software residing on the machine itself. While this does not limit the data that can potentially be accessed over the internet or through a network, a software license is usually required for each individual machine or needs to be available through a license server. Desktop GIS tools usually provide the most functionality when compared to web-based or mobile GIS and are used for comprehensive GIS analysis, specialized cartography, 3D and visualization applications, and enterprise GIS data management. Examples include: ESRI's ArcGIS suite, Intergraph Geomedia, Mapinfo, and AutoCad Map.

Web-based GIS refers to GIS applications served over the internet or intranet (i.e., private network). End users usually do not require GIS software to be installed on their computers and the application can be accessed with an internet connection from anywhere. While functionality usually does not include comprehensive GIS analysis, this type of GIS makes tools available to a wide variety of users without the need for numerous software licenses. This type of GIS deployment works well for casual users, and for organizations that either cannot make a substantial investment in purchasing software and/or require a lot of users to have access to GIS functionality. Examples of this kind of software/application include ESRI's ArcGIS Server (ArcIMS) and Google Earth.

Mobile GIS refers to GIS applications that can be taken into the field or to any location usually not connected to a network. Current mobile GIS applications use GIS software designed to integrate Global Positioning (GPS) functionality with GIS-based data collection. Additionally, the increased availability of wireless networks will eventually lead to most mobile applications to have a web-based component. Many of these applications provide a map-based interface and can run on a laptop, tablet PC, or GPS unit. A good example is ESRI's ArcPad application that runs on a higher end GPS unit.

3.6 - Components of GIS Data

GIS data generally consist of three major components: location, geometry, and attributes. **Location** refers to the position of the feature in geographic space (X and Y). **Geometry** refers to the shape of the feature. Together, location and geometry define a feature and its relationship with surrounding and overlapping features. The **attributes** of a feature refer to the information that is associated with that feature, often referred to as **business data.** Referring to the earlier example of the proposed road alignment and parcel ownership, the location and shape of the parcels provide the spatial information, while the ownership details (i.e., who owns the parcels, address information, etc.) are the business data that are now linked to a geographic location. The structure of GIS data allows for the business information to reside directly associated with the geographic information.

3.7 - Linear Referencing of Location Data

Another way location information is defined at the Department is through the use of **linear referencing**. UDOT's Location Reference Standard (LRS) defines locations along the State road network, a method that is compatible with GIS. Even though most GIS data are based on features (with associated geometries) defined in geographic space through X and Y coordinates, routing as a concept is very common in a GIS. For example, locations along roads (such as street addresses) are commonly referenced in GIS through a process called **geocoding**. The geocoding process takes the location of a feature (for example a house) and plots its location in the appropriate spot along the street center line GIS file using the underlying attribute of the street layer that indicates the range of house numbers associated with that particular stretch of road. LRS is no different. When LRS descriptions are linked with the appropriate road geometries in GIS, these LRS defined locations can have coordinates associated in geographic space and become fully functional for GIS analyses. In short, LRS defined locations are GIS compatible and vice versa and thus should be considered part of the overall GIS functionality at the Department.

3.8 - GIS Datasets

There are many data types and formats that can be displayed and analyzed using a GIS application. They generally fall into two categories: personal (portable) datasets and enterprise datasets. A common example of a **personal GIS dataset** is ESRI's shape file format. **Shape files** have location and geometry definitions, while storing attribute information in an associated database file (dbf). While GIS analysis using shape files is possible, the attribute information is not actually stored in an enterprise relational database (such as Oracle), and any edits or modifications to the data are only reflected in the shape file you are editing. It is however a format that lends itself very well to personal analysis and data transfer. In addition a lot of datasets are not linked to a relational database to begin with. Many agencies have personal GIS datasets available for download over the internet. For example, a two foot contour topography shape file available for download for a specific area contains the elevation values for each contour as a primary attribute within the shape file itself. This information works well as a personal dataset, since a relational database link might not be relevant, nor is it likely that this information needs to be edited. Other examples that work well as stand-alone datasets are city boundary information; soil types; floodplains; and census or voting districts. **Personal geodatabases** are ESRI's next generation personal datasets, providing functionality for linking datasets and establishing feature links within a stand-alone structure.

Enterprise GIS datasets store GIS data in a relational database usually through a spatial data engine. A common example is ESRI's ArcSDE linked to an Oracle database. In this example the data attributes (business data) are stored in Oracle, while the ArcSDE engine links the Oracle business data to the spatial definitions (location and geometry) in a format that the GIS software can access. For an organization like UDOT, with key business data about the road network already stored in Oracle, most datasets will work best in an enterprise environment. Additionally enterprise data structures allow the data to reside in one spot, thereby preventing redundancies; data duplication; and the use of outdated or incorrect information. An added benefit is that the same business data in the Oracle database (such as pavement information, STIP projects, AADTs, etc.) can be used in both LRS and geographic coordinate based applications.

3.9 - GIS Data Formats

The two main data formats used in GIS are raster and vector. **Raster** data are pixel based and include aerial photography, digital terrain models, or triangulated surfaces. **Vector** data consist of points, lines, and polygons. CADD data also fall in the latter category. Most GIS software can directly display CADD information (dwg, dgn, dxf). Whether the data will "correctly" overlay is dependent on the compatibility of the geographic referencing of each of the datasets.

3.10 - GIS Data Accuracy and Metadata

There is a vast amount of GIS data available to the public, most of it directly downloadable over the internet. The sources of most of these datasets are federal, state, and local government. The AGRC website provides a good overview of all available data for Utah (http://gis.utah.gov/agrc). Since there is no "minimum accuracy requirement" for GIS data, the accuracy of the available data will vary. However, this does not mean that lower resolution data is not useful, since some datasets are meant to be viewed at a certain scale. For example, the 1:500,000-scale statewide geologic map of Utah provides a good overview of surficial geology and locations of fault lines across the State. However when the GIS layers from this map (i.e., fault lines, surficial geology polygons) are viewed in a GIS and a user subsequently zooms in on a small area like the Sugar House neighborhood in Salt Lake City, the locations of the fault lines and the geologic unit boundaries are probably not in the right location. This is because the dataset was created at 1:500,000 to be utilized at 1:500,000. In order to understand what a GIS dataset is meant to be used for and at what scale, it is important to review the **metadata** before using the data. A metadata (data about data) file, describes the information about each GIS dataset including data source, data accuracy, the year the data was produced, the scale the data should be looked at, the coordinate system of the data, who to contact for questions, etc. All good GIS data should have an associated metadata file. Metadata is usually stored associated with most datasets that are available for download.

3.11 - GIS Data Compatibility and Data Standards

Spatially referenced data come in many different formats. Even though most GIS software can read a variety of formats, in most cases data manipulation needs to take place to provide a standardized format or projection (e.g., coordinate system) for analysis. Most organizations have standards and procedures in place for data management and collection to facilitate these conversions. These standards, together with data access and security regulations, are usually integrated into existing organization standards.

3.12 - The GIS User

There are many types of GIS users, ranging from application developers with a computer science background, geographers with a GIS background, engineers and environmental professionals dealing with specific data, to casual users who need answers without having to do comprehensive data management and analysis. Upper level managers usually fall in the latter category, where GIS is applied as a tool for high level decision making with a focus on the big picture. All these different users can be served by GIS technology simultaneously within an organization as long as the available data are current, correct, available, and accessible. Additionally, to aid any (potential) GIS users there are numerous excellent educational and self-study opportunities available to learn more about GIS and associated technologies and applications.

3.13 - The Main Uses of GIS

The three main uses of GIS are data or asset management, spatial analysis, and cartography. Examples of **data or asset management** using GIS include: managing networks (such as utilities and roads) or facilities using GIS tools while incorporating all aspects of these assets (e.g., pavement type, AADT, planned improvements etc.) usually through enterprise (business) database connectivity. This could also involve the verification (QC/QA) of locations stored as coordinates in a database. **Spatial analysis** uses the geographic relationship between features to get valuable information, such as the process of quantifying the impact of road alignments on sensitive wetlands, cultural features or floodplains through a spatial query. Other examples include commercial or industrial siting studies; and preferred housing location searches used in the real estate industry. Finally, most desktop GIS packages have very sophisticated **cartography** (map design) capabilities to provide the user with the capability to create state-of-the-art maps and displays, often including 3D Visualization. GIS maps can also easily be enhanced using graphic design packages such as Adobe Illustrator. Most organizations are using all three components as part of their day-to-day business and most GIS software is designed to do all three.

Section 4 - Why should UDOT promote the use of GIS?

4.1 - GIS in Transportation

As mentioned in Section 3, the evolution of GIS technology over the last 10-15 years has led to a significant increase in the amount of available data, applications, and end users. Realizing the potential that GIS technology provides for large organizations, most government agencies have developed, or are in the process of developing, a strategy for GIS implementation. State DOTs are no different and since the road network is inherently a geospatial entity, this makes a lot of sense just from that perspective alone. Currently 24 DOTs across the country have GIS Strategic Plans in place and 20 DOTs are currently in the process of developing such a plan. Most DOTs have already significantly invested in GIS in conjunction with database applications and are looking for direction to formalize and optimize their investments and validate their role in Department business processes. More and more DOT managers are realizing that GIS concepts are already interwoven throughout transportation agency functions and that the introduction of GIS does not constitute “a new way of doing things”.

GIS in Transportation is a national industry that is rapidly growing. The annual GIS-T conference is entirely focused on GIS applications and strategies at DOTs and is organized for and by State DOTs, FHWA, and AASHTO. The investments being made by DOTs nationwide and the software and applications that are being developed both in-house and by specialty software companies illustrate that it is not a matter of “if” a DOT will use GIS technology, but “when”, “how” and “using what strategy,” since the list of business benefits and potential applications are endless. The AASHTO GIS-T conference website (www.gis-t.org) lists a great deal of useful information and contains archives of all breakout sessions and presentations for the last six conferences.

4.2 - Business Benefits

Uniform access to spatial data linked to many databases within the Department, and from outside sources provides the following direct and indirect business benefits:

- **Quicker access to better data leads to more efficiency and productivity, and less redundancy.** When UDOT staff need certain GIS data to accomplish a business function, the time gathering (or creating) the needed data is eliminated if this data is readily available. An example could be when someone needs the location of key Statewide Transportation Improvement Program (STIP) projects. Rather than finding a hardcopy map, or asking someone to create a layer containing the information, a GIS coverage with associated details can be downloaded from an Intranet portal or plotted directly via an online viewer. The data is available right away and a potentially inaccurate duplicate layer does not get created. This also eliminates a lot of faulty assumptions. Additionally, duplicate and redundant information almost always leads to data integrity issues.

- **Integrating GIS tools with Department business systems facilitates the capture of important institutional knowledge**. Just like any other government entity, UDOT is faced with the loss of key institutional knowledge through staff turnover, in particular the loss of key people with many years of experience. Capturing this knowledge ahead of time by linking this data to the asset through the integration of GIS tools organizes the information in the appropriate location. This allows for intuitive an easy access of data, which is especially important when new staff need to get familiar with what data to use.
- **Access to uniform data across the Department leads to a consistent "base" on which decisions are being made**. For example, if all divisions, groups, and regions are using the same master road centerline GIS layer (linked to Department business systems and LRS), the results of any analysis or any newly generated GIS information will be compatible and consistent with other Department applications.
- **Integrating business data using GIS reduces data errors**. Data inaccuracy or incompleteness will be quickly noticed by many users across the Department. For example, when a bridge located in Salt Lake County, is plotting in Moab through GIS and has the wrong bridge ID number, a correction can be made in the master bridge database (Pontis). Fixing these inaccuracies in the source database means that the same problem will not arise again. Moreover, conclusions based on a spatial analysis identifying critical bridges will not potentially omit this bridge, just because the associated coordinates are incorrect.
- **Quick access to integrated information can be critical in emergency situations.** When emergency situations present themselves, ranging from terrorist threats to natural hazards such as flooding or earthquakes, GIS functionality can significantly reduce the time to analyze the situation, mobilize personnel and equipment, and inform the public. For example, during a flooding situation, all bridges in danger of collapse within a certain watershed or radius can quickly be identified, detour routes can be calculated and crews can be dispatched to exactly the right locations armed with the right knowledge.
- **Access to multiple key datasets simultaneously leads to better decisions.** It is easy to make misinformed decisions when conclusions are based on limited information or when key datasets are not available to compare spatially. Why replace the pavement on a stretch of road as part of a scheduled maintenance project, when there is a construction project scheduled on the same stretch of road a few months later, requiring the (brand new) pavement to be replaced again?
- **Making mobile GIS tools available to field staff improves the accuracy and efficiency of the data collection process.** Through the use of GPS technology, and associated field GIS applications, data collection in the field can be quickly and more effectively completed. Key attributes associated with a feature can be entered in the field through a data dictionary associated with the data set and programmed in a GPS unit or tablet PC.

- **Leveraging datasets that UDOT already paid for allows for future project savings and better informed planning.** UDOT creates a lot of GIS data either in-house or through consultants. Good examples are environmental and NEPA studies such as large EISs in urban areas. Currently, the collected data such as detailed wetland delineations, cultural inventories, land use data integration from multiple cities and custom aerial flyovers resulting in high resolution imagery are inadequately captured by the Department. Leveraging these datasets into a UDOT GIS environment provides better information for planning subsequent projects in the same geographic area and can significantly reduce the cost of data collection for a study in an adjacent or overlapping area.
- **Having reliable data available in an integrated GIS environment allows for more complex analyses to be performed.** Complex analyses that might have required a specialty consultant in the past can be performed using GIS tools when the necessary data is available. Also, when a specialty consultant is needed, the source data needed for the analysis in question could already be compiled, which potentially eliminates the data collection cost associated with funding the consultant’s services.
- **Optimizing past and current GIS investments leads to a better and more focused future funding strategy.** UDOT has invested significant dollars in initiatives and projects involving a GIS component. Improving the coordination between groups, divisions, and regions on these initiatives and implementing an integrated GIS strategy will likely lead to more focused initiatives and reduce instances where the “wheel is being re-invented.” As mentioned before, GIS concepts have been used for years across the Department to support business functions, albeit often not in an integrated manner. This also provides proof that a sound GIS strategy for the Department does not necessarily have to involve starting “something new.”
- **Integrating outside GIS data becomes easier with an integrated GIS structure.** There is a tremendous amount of GIS data available outside of UDOT that is relevant to UDOT’s business. UDOT can benefit from data that is already developed by other government entities. Environmental data, census data, land use and zoning data and FEMA floodplains are just some examples. Linking these datasets seamlessly with GIS data generated within the Department is much easier to accomplish within an integrated Department GIS structure with established data standards. UDOT could also forge partnerships with other agencies and share the responsibilities of updating and maintaining specific datasets.
- **As the custodian of state transportation information, UDOT GIS data should be the standard for outside use.** GIS information about the State road network is being used by numerous public and private entities across the state, but often this information does not originate at UDOT. While the proper protocol needs to be in place on what data can and cannot be shared with the general public, basic information about Utah’s road network should originate from UDOT

and made available to the public via, for example, a partnership with the AGRC. The role of UDOT as a data steward needs to be investigated accordingly.

Section 5 - Current Status and Challenges

Since the data UDOT staff is dealing with on a daily basis involves the state and road network and all associated assets and business data, it is vital to link the locations along the road network to these business data. Locations are currently defined by either the LRS, geographic coordinates or both. While the LRS has been adopted as a standard for UDOT in managing and referencing the State road network, there is currently no clearly defined direction for dealing with GIS information at the Department. The following section outlines the main differences and associated challenges of dealing with the LRS and geographic information respectively.

5.1 - The UDOT Location Reference Standard (LRS)

The LRS is considered UDOT's standard way of referencing locations agreed upon by UDOT management and the associated compliance of applications is considered a Department metric. LRS definitions are based on mileage and reference posts along roads within Utah's road network providing locations which are linked to the associated business data housed in Oracle databases.

- Using the LRS, locations along a road are defined using:
    - Date
    - Route or Zone Number
    - Direction
    - Roadway Type
    - Interchange Number
    - Roadway Number
    - Lane
    - Concurrent Accumulated Miles
- The advantages of using LRS definitions include:
    - The LRS is intuitive. A definition of a location based on the distance along a road using mileage and associated reference posts provides staff with a location one can drive to using a State Highway Map, not needing a GPS or similar device.
    - The LRS is organized and structured. The Department has detailed instructions on how to capture data and define certain segments of the road network. A great deal of emphasis has been placed on keeping these standards relevant and up-to-date.
    - The LRS is well integrated with Department enterprise business (Oracle) databases, providing users with a straightforward connection to relevant business data.
    - The inherent structure of the LRS and its non-dependency on road geometries to define a location along the road network does not pose significant challenges as far as attributing business data to specific segments along the length of a road.

- While the LRS provides a powerful and intuitive way of referencing locations, its associated challenges include:
    - Keeping track of changes in LRS definitions and displaying associated data correctly. When mileage and associated reference posts along the road network change, associated data such as accident locations could potentially be referenced incorrectly. The same could happen when a road gets shortened or realigned.
    - Transferring LRS definitions to road geometries in geographic space requires a reliable spatial road geometry definition. Defining a location using LRS methodology does not allow for the shape of (and bends in) the road itself to be captured. This makes LRS defined data somewhat difficult to "visualize" since a geographic definition or spatial interface is not inherent to the format itself.
    - Information that does not fall on or near the road network is difficult or impossible to capture through LRS methodology, requiring a conversion from LRS defined data to a geographically referenced system. Examples of these type of data useful to UDOT staff include:

        - Municipality boundary outlines
        - FEMA floodplains
        - Water features and drainage basins
        - Utility locations
        - Parcel outlines and ownership
        - Census blocks
        - Soil types and geology
        - Rail Roads
        - Nearby sites of environmental concern
        - Elevation contours or DTM/DEM data

        While one could argue that the purpose of the LRS does not include capturing these types of datasets, it is often necessary to compare or overlay LRS based data onto these other datasets in UDOT's day-to-day business processes.
    - LRS definitions don't always incorporate detailed elevation changes along the length of a road. Care should be taken when projecting the mileage defined in the LRS onto 2D geographic space. This can be achieved through the use of a detailed GIS layer depicting Reference Posts based on GPS locations in conjunction with the (2D) road geometry.

5.2 - Geographically Defined Information

This type of data, often referred to as "GIS data" is based on location definitions using geographic coordinates and geometries (shapes).

- The following major benefits with regard to the use of GIS data at UDOT are:

  - Geographic definitions can define features and their geometries (shapes) unrelated to and/or not located on the road network.
  - Geographic locations are compatible with most other geographic information or GIS layers.
  - Using a GPS you can collect, find or plot any coordinate, whether or not you are familiar with the area and road network.
  - Through proper data management, GIS data provide a wealth of information about the real world, not limited to transportation applications.
  - Linking GIS data based on geographic coordinates to enterprise data systems (Oracle business data) is possible through spatial database connectivity software or by storing the geometries and coordinates within Oracle itself.

- While providing many benefits, GIS data present an entirely different set of challenges. There is a wide variety of GIS layers being used at the Department at this time which are currently not tracked systematically and are only minimally standardized. In addition, these datasets are often stand-alone shape files, not linked to enterprise business data. The power of geographic data in GIS format is, at the same time, its biggest liability. GIS data is easy to store, convert, create, and edit; and above all, there is a lot of GIS data available from various sources very often directly downloadable from the Internet in shape file format. This leads to the following challenges:
  - GIS data are residing throughout the Department, its locations ranging from network servers to individual work stations. While it is inevitable (and in some cases desirable) that custom datasets are being generated and maintained outside of any enterprise structure, key GIS layers describing the State road network should be consistent across the Department and be maintained by the division or group responsible for maintaining those datasets. Such a protocol is currently not established, making inaccuracies and inconsistencies in those layers difficult to avoid. Duplicate, non-identical datasets get created, that subsequently propagate throughout the organization.
  - Data, either downloaded or Department-generated, acquired at different dates, for different purposes, with inconsistent geographic coverage, and without proper documentation often get used for the wrong purpose. This could potentially lead to inaccurate assumptions and conclusions affecting business decisions.
  - Reference system issues are commonplace. GIS data can be referenced to many “real world” coordinate systems (e.g., UTM, State Plane), local (design) coordinates, or no coordinates at all. Additionally, there can be mistakes and/or assumptions regarding the coordinate systems and datums, wherein data is projected. For example, there is an offset between NAD 27 and NAD 83 UTM coordinates that is less than half a mile. When users are dealing with unfamiliar data, these things could go unnoticed and incorrect decisions might be made as a consequence.
  - GIS data can be created very easily. Drawing a line in a GIS desktop software package and storing it as a feature class or shape file assumes

its existence as a GIS layer. Without proper documentation, someone might assume that a road centerline roughly digitized off some aerial photo is an “official” road centerline depiction while it is not.

- While the link between LRS definitions and Department business data is currently established, this same link is not established with all geographic layers used in the Department. As discussed in Section 4, very few portable datasets (such as shape files) are linked to a relational database in an enterprise environment. This is not to say that portable datasets should not exist; they have there functions and use in GIS data management. It just makes the access to accurate business data associated with these features less straightforward and more error-prone.
- Since the LRS is established as the standard way of defining location information along Utah’s roads, any coordinate based location depictions need to be compatible with LRS definitions, a process that although feasible, is currently not formally established.
- Some location information along the State road network is easier defined using the LRS and can subsequently be converted to GIS coordinates. The same is true for the opposite in some cases. There is currently no protocol that defines the “preferred” method for capturing initial locations using either the LRS or GIS/GPS tools.
- Related to all of this, reliable metadata is often missing; incomplete; or not stored/downloaded with the data.

5.3 - Current GIS Staff

The ETS section at the Calvin Rampton Complex currently includes GIS staff that support the Department in a variety of ways, ranging from custom GIS requests and data management, to deploying web-based GIS applications mostly using ESRI software. Several other groups, divisions, and regions have staff proficient in and assigned to GIS data management.

5.4 - Current GIS Software

UDOT has invested in many GIS software licenses, most of which are part of ESRI’s ArcGIS suite. These include desktop ArcGIS licenses, ArcSDE (spatial connectivity with Oracle or other RDBMS), and ArcIMS (ArcGIS Server) to deploy GIS enabled websites. The desktop licenses in particular (ArcGIS) are installed and used throughout the department. In addition, in conjunction with UDOT’s past and present investments in Oracle relational database technology, Oracle Spatial is being used by UDOT DTS staff. Google Earth and other online applications not hosted within the Department do not require any software purchases (for the basic versions), since they are accessed over the web from outside servers.

5.5 - Current GIS Applications

The Department has many applications and/or initiatives that either have a significant GIS component or use GIS concepts. Examples include but are not limited to:

- OMS (Operations and Management System), including (mobile) GIS initiatives for Maintenance Management Quality Assurance Program (MMQA) and Maintenance Feature Inventory (MFI)
- Geographic Transportation Environmental Assessment System (GTEAS) (web-based, partnership with ESRI and AGRC)
- Systems Planning and Programming (SPP) System (route network (LRS), roadway, features, and traffic)
- LRS Online
- Traffic and Safety and permitting
- Utah Bridges web portal (inventory, emergency, and port-of-entry) inventory system (web-based)
- Planning Data Management and Presentation Tool
- Google-based applications such as the rest area viewer
- Inventory of traffic signals and pedestrian ramps
- Energy use mapping (Google Earth / ESRI)
- Airport Mapping
- STIP
- Fiber Optic and Automated Management Traffic System (ATMS) Mapping
- Gravel pits (web-based)
- State Highway Map
- B&C Roads Inventory (AGRC partnership)
- Right-of-way
- Roadview
- ePM (links to maps and GIS data)

One interesting conclusion coming from the visioning workshop was that not everyone attending was aware of these applications and initiatives. This indicates that most of these applications are developed and used within one division or group only. Responses to the question what available GIS data was used on a regular basis and what data would people like to be available, yielded a long list of GIS (compatible) datasets in both categories, often with significant overlap. This means that these datasets are likely not standardized and not readily available across divisions. It is also possible that the quality, extent, or resolution of the data might be adequate for one purpose/division, but not for another. Finally, some of the requested datasets are readily available from the AGRC. In this case, people might not know what is available outside of UDOT. Appendix A includes a full list of the identified datasets and applications during the workshop.

5.6 - Perceived Challenges

Using feedback obtained at the workshop UDOT staff perceives the major challenges to an integrated GIS structure to include:

- **Identifying Benefits.** The benefits of using GIS are not clear to everyone, making it harder to get management and/or funding support. This is either due to a vague or non-existent implementation strategy, or a “bottom-up” implementation rather than a “top-down” strategy starting with the business benefit.
- **Lack of Training and Technical Support.** Participants do not believe they have enough training to use GIS software data in a meaningful way. Lack of technical support was also identified.
- **Data quality, integration, availability, access, and completeness.** Participants questioned the quality of the available data; whether the data is current and complete; the lack of data(base) integration; and the access to and availability of critical data, which is hindered by data access barriers and the lack of a “sharing of information” culture. People usually create their own (not necessarily accurate) data to do their job if they do not have access to the “master” data**.**
- **Data updating, ownership, and accountability.** There currently is no established protocol as to who updates what GIS compatible data. There is not a culture of accountability (i.e., division X needs to keep dataset/database Y current and GIS compatible, because the rest of the Department depends on that data being accurate, updated, and available for their business processes).
- **Getting needs appropriately prioritized.** Some people might want to use GIS, but do not feel they get the support and prioritization from within the Department to make the implementation of either performing GIS analysis themselves or receiving adequate and timely GIS support, worth their time and effort.
- **Outreach on available data and capabilities.** People are not aware of what data is available (and where) to use in a GIS environment and what tools are available for data viewing and analysis (“how can I use GIS to my benefit if I don’t know what is possible and available?”).

Section 6 - Goals, Recommendations, and Next Steps

6.1 - Goals

Using gathered information and the feedback from UDOT staff, the following nine goals were developed. These are addressed in detail in this section of the GIS Strategic Plan to help move the process of GIS awareness and integration at the Department forward. These goals and associated recommendations have been prioritized as follows with input from the GIS Steering Committee:

1. **Establish an accurate set of basic spatial (GIS) information (a "master" dataset)** describing the UDOT road network and associated assets for Department-wide use, with the goal of increasing data accuracy, establishing consistency, and reducing redundancy.
2. **Establish appropriate data security, QC/QA, and documentation protocol** for spatial data in the department.
3. **Optimize the integration of existing UDOT business data systems (such as ePM, OMS, PDBS, Pontis, etc.) with GIS tools**, with a focus on data maintenance responsibility and accountability.
4. **Optimize the use of existing GIS business applications and datasets** creating efficiencies in application development and data collection. This also includes capturing datasets UDOT paid for, but does not utilize to its full potential.
5. **Optimize field data collection methods** for specific datasets.
6. **Optimize UDOT's relationship with the AGRC,** focusing on application development, technical support, and spatial data creation and management.
7. **Establish a staffing strategy** that optimizes and utilizes current UDOT FTEs and Department contractors, focusing on a stronger integration and coordination with ISS/DTS staff and better defined job responsibilities.
8. **Develop an online portal providing UDOT staff access to business data through GIS.** This will allow users to either download, view or analyze Department information in GIS format via an online map-based interface, providing easy access to Department information for anyone that needs it.
9. **Establish an outreach strategy** that promotes the use of GIS by Department staff to achieve efficiencies in UDOT's day-to-day business processes.

6.2 - Recommendations

Goal 1 - Establish an accurate set of basic spatial (GIS) information (a "master" dataset)

This master GIS dataset should consist of accurate and standardized geographic definitions of UDOT's key assets such as the road network, bridge locations, etc., both for current and historical locations (if appropriate). Having a master GIS dataset available (and possibly mandated) for use on Department GIS activities, has two important advantages. First, it ensures that everyone is using the same information; second, since everyone is relying on this information to be correct, it is critical for the division/group that is responsible for these location data to keep the data current, accurate, and available to the rest of the Department, which improves data QC/QA. The major disadvantage of not having master datasets, either due to data availability/access or data quality/accuracy issues, is that people will create their own datasets. These datasets will either be derived from master data or downloaded/created independently. In both cases, the data will not match the master data and Department business will be conducted on multiple non-identical datasets with all associated consequences.

The following actions are recommended to ensure this process is successful.

- ❖ **Determine what GIS information needs to be included in the master GIS dataset** through carefully analyzing potential uses of GIS datasets as they relate to UDOT's business processes. The State road network available as integrated and connected lines defined both as a geometry (shape/direction) and in geographic space is probably the single most important piece of GIS information for the Department that needs to be included in this dataset. As mentioned before, the myriad of different versions that currently exist create multiple inconsistencies since most GIS users across the Department use (a version of) this GIS layer, either linked to LRS definitions and business databases or as a stand-alone shape-file with varying attributes. Other examples could include bridge locations, reference posts, environmental data, as well as GIS data originating outside of UDOT.
- ❖ **Inventory all major GIS layers currently being used** and evaluate whether they could and should be standardized for Department-wide use as part of the master dataset, even if data is currently not stored in an enterprise environment. Additionally, non-Department data should also be regulated wherever possible. For example, everyone should use the same Wasatch Front Regional Council GIS information, UTA rail alignments, or the most recent municipality boundaries obtained from the AGRC. This requires close coordination with other agencies and entities, specifically those working in the transportation arena.
- ❖ **Foster a culture of information management accountability.** Many divisions and groups within UDOT rely on accurate information. Whoever has the responsibility for maintaining and updating a key business database and

associated GIS information should be held accountable for timely updating and keeping that database accurate and complete**.**

Goal 2 - Establish appropriate data security; QC/QA; and documentation protocol

- **Data Access and Security**
    - **Public access to data.** An evaluation needs to be conducted to determine what data should be available to the public and what data are for internal use only. For example, rest area locations are shared with the public, while key bridge risk assessment data are not, because of the associated security concerns.
    - **Sharing data within the Department.** While some information possibly shouldn't be shared within the Department, basic information about key assets should be available to the UDOT staff that need it, with some key fields/attributes queried out if needed for security reasons.
    - **Data editing / modification privileges.** Currently Department data is edited by both GIS staff and the division that maintains the dataset. This responsibility should shift entirely to the latter. Department-wide GIS staff should not fix GIS information for internal customers. Instead the data reaching the GIS staff should be accurate already and have been through a QC/QA process within the division/group that is responsible for maintaining that particular database
    - **Dealing with proprietary databases.** When a database is proprietary (e.g., Pontis) a separate database will have to be used to allow for enterprise integration not possible with the proprietary database. In this case, it is important to synchronize the data often to allow for the latest information to be available to users across the department.
- **QC/QA.** The concept of GIS-enabled master data(bases) available for people to use in their day-to-day functions only works if the data is accurate and up-to-date. This is only possible if the responsible division provides quality control on the data, specifically on the spatial definitions. This not only includes verifying that associated X and Y coordinates or LRS definitions are correct, it also means verifying that feature IDs (such as bridge numbers) are correctly attributed in the database and that new features are added in a timely manner. An enterprise GIS system often uses feature IDs to link the business data to geographic features. The bottom line is that people will not use datasets they know are inaccurate and incomplete and will either edit (a copy) of a master dataset or create their own. It is recommended that a formal QC/QA plan is established for each major dataset that is used Department-wide and that existing LRS Standards are expanded to include language on GIS.

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- **Documentation.** Having access to data that is accurate and of a high quality does not necessarily mean this data is going to be used for the right purpose or that correct assumptions are being made by those using this data. Having proper

documentation (metadata) available about datasets is therefore an essential third component. Metadata should include, as a minimum, the source, date, spatial reference, contact information, and purpose of each dataset. This will allow Department staff to use the data appropriately. For example, information on the (low) resolution of a dataset can prevent “non-survey grade” elevation contour data being used for engineering and design purposes. Metadata should be captured using a standardized format and stored with the datasets themselves.

Goal 3 - Optimize the integration of existing UDOT business data systems (such as ePM, OMS, PDBS, Pontis, etc.) with GIS tools.

To provide GIS users across the department with consistent information that is available, accessible, up-to-date, and linked to business data and LRS, the following actions are recommended:

- **Optimize relationships between existing business data systems base on common assets** to allow for Department data to be available to the GIS user in an integrated, common framework. Most of UDOT’s business data are housed in Oracle databases. GIS software can be linked to Oracle business data through the use of a spatial data engine. A spatial data engine (such as ArcSDE) can link geographic features to their corresponding enterprise business data and allow the GIS user to query these business data using geographic locations of the features in ArcGIS or over the web. UDOT is already using ArcSDE for some of its applications. To achieve the objective of serving Department business data to the GIS user through a spatial data engine, relationships between UDOT’s Oracle databases need to be established “behind the scenes”. This does not mean that all data should be in one location managed by only a handful people with administrative access without any flexibility. Each division is still responsible for their own business data. However, these data should be linked to other Department data based on common attributes, allowing for access throughout the Department using GIS tools. For example, if the planning group needs bridge location data with some key attributes, this data should come directly from the structures group, whose data is directly linked to (or frequently synched with) the source data in Pontis. This creates data consistency, while eliminating data redundancy and errors when data is edited “away” from the master data.
- **Have the same Department databases serve both LRS and GIS end users** to allow for the same underlying business data to be accessed, independent of the location referencing method used for either data collection or data access. This requires a protocol for intelligent conversion of LRS definitions to GIS coordinates (and vice versa) to capture all related business data.
- **Create a protocol for editing spatial data.** Having the same Department business databases serve both LRS and GIS based spatial definitions requires standards and protocol to be established that regulate any spatial data modifications affecting data integrity. Careful consideration should be taken when editing geometries and spatial characteristics associated with enterprise datasets

in the GIS desktop environment or when different versions of the same data (need to) exist. Additionally, if someone wants to edit master geographic data because it is deemed inaccurate, a request should go back to the division responsible for the maintenance of the dataset in question, rather than individuals outside that division changing (a copy of) this dataset. When each division is held accountable for maintaining accurate and up-to-date data, it is expected that these problems will occur less frequently.

- **Create a seamless location definition conversion process** to allow for location based data to be available in the preferred format (LRS or geographic) as determined by the business process and/or end user preference. UDOT staff that use the LRS as their main location reference need to have access to location data collected through GIS/GPS by having that information converted for use through the LRS and vice versa. Ideally this process is transparent to the end user.

Goal 4 - Optimize the use of existing business GIS applications and datasets

Optimally using current and past investments in GIS related development, applications, and data will not only save the Department significant money, it will also lead to improved consistency between information management applications and a more efficient use of in-house or consultant staff responsible for collecting and creating data, and developing applications. The following recommendations should help achieve this goal:

- **Conduct a detailed evaluation of existing GIS applications.** The purpose of this task would be to evaluate whether certain applications developed for a specific purpose or division can serve another purpose / division with some minor adjustments, thereby saving funds that otherwise might have gone to a brand new application or project. While it is true that some business objectives might require the development of a brand new application, knowing what has been developed before could, as a minimum, provide a head start or a framework to start building on. In the best case in-house staff could modify an existing application to serve the particular business need. In general, in-house applications should not be developed "bottom up," but rather from a "top down" perspective, where the potential broader use of an application is kept center stage from day one.
- **Evaluate already existing specialty software specifically targeted towards GIS in Transportation.** When evaluating the need for an application to be developed in-house or through a consultant, it is important to scan the market (or inquire with other DOTs) for specialty software that has been developed already for the business need in question. This could be a more economic option.
- **Optimize the use of Google (or similar) applications.** Online applications such as Google Earth provide a cost effective solution to present information to a large number of people including the public with minimal maintenance. These types of solutions are a good fit when relatively static information needs to be displayed

and limited analysis capabilities are required. UDOT's online rest area viewer is a good example of this.

- **Capturing datasets that are owned and paid for by UDOT.** There is a lot of data being generated using transportation funding, whether it is the purchase of aerial photography for a design project; NEPA information generated as part of an EIS; or as-built and other CADD data. UDOT currently does not have a system in place to capture and leverage all this information. With all this GIS information available as a resource, better planning decisions can be made and money can be saved when scoping another project in the same area with key data possibly already collected and available for use. To accomplish this the following actions are recommended:
  - Inventory existing project data.
  - Require in-house, consultant, or vendor staff to submit newly created or acquired GIS data to UDOT at the end of each project.
  - Establish metadata, format, and geographic reference standards for these dataset submittals and make them a regular project close-out requirement, which should be listed as such in RFPs.
  - In the RFP stage indicate the availability of relevant project area datasets to interested consultants and request a scope based on certain datasets already available instead of funding the creation or collection of new, potentially duplicate, data.
  - Establish an aerial photo image server for GIS access and require every consultant or vendor to provide the digital aerial photography files to UDOT when this imagery is obtained on project funds. Organized using a Department image server, these (historic or recent) aerial photos should subsequently be available as a resource for future projects. While there is a great deal of high quality statewide aerial photography available already, project specific aerial photography is often at a higher resolution. It is again vital to maintain good metadata and organization for these files, since geographic coverage will vary.
  - Identify ways to incorporate CADD data as a GIS resource either through georeferencing actual project/road alignments or by storing CADD plans and as-builts as pdf files in a database associated with geographic locations. Digital photographs can be feature-linked in a similar fashion.

Goal 5 - Optimize field data collection methods

- **Inventory current data collection methods** (including standards and requirements). Evaluate whether it makes sense to incorporate GPS methodology or to go all-digital in performing inspections, inventories, etc.
- **Establish a formal data collection protocol** for each critical dataset and determine whether data collection is more efficient using either GPS units (with data dictionaries) or LRS based. Since a conversion between geographic coordinates and LRS definitions is expected to be seamless for Department databases in the future, the focus should be on the most efficient way in which data can be collected at the appropriate level of accuracy.
- **Train field staff on the use of (new) data collection techniques** finding a balance between technological advantages and ease of use.

Goal 6 - Optimize UDOT's relationship with the AGRC

The AGRC, a DTS division, is the steward of Utah's Statewide GIS database, working collaboratively with government and private entities across the State to facilitate access and availability of geographic datasets in Utah. The AGRC is currently preparing Utah's Geospatial Strategic Plan. UDOT is currently collaborating with the AGRC at various levels and a close partnership between UDOT and AGRC has obvious mutual benefits. Optimizing the current relationship could be accomplished through the following:

- Allow the AGRC to provide appropriate UDOT datasets describing the State's transportation network and its assets to the public. An evaluation needs to be conducted to determine which datasets are appropriate for public viewing and access.
- Focus on forging more partnerships in both strategic initiatives and data collection/creation efforts. The ongoing initiative to create a reliable GIS layer for state B and C roads is a good example of the latter.
- Evaluate where it might make sense to partner with the AGRC on data storage or application development. Establishing an online GIS portal for UDOT (see Goal 8) could possibly be a good opportunity for such collaboration.
- Provide joint outreach and training to UDOT staff with regard to the availability of datasets, technical issues, and how Utah government can best benefit from developments in GIS technology and applications.

Goal 7 - Establish a staffing strategy

Implementing an integrated GIS strategy requires dedicated staff. While some strategic plans at other DOTs recommend hiring several new FTEs to achieve this objective, UDOT is best served by using mostly existing staff, possibly augmented by a key hire. UDOT currently has very knowledgeable and experienced GIS staff both at the Complex and the Regions. Additionally, UDOT DTS staff possess a wealth of database and application development knowledge. To optimally leverage these strengths and meet Department GIS integration objectives the following actions are recommended:

- **Improve coordination among GIS staff throughout the Department.** In the current situation there are no clearly defined relationships among GIS staff in the ETS section and GIS staff in other divisions and each of the Regions. Centralizing all GIS staff in one division is not feasible, nor is it desirable. Staff dedicated to one division, group or region allows for GIS knowledge to be available throughout UDOT, which also facilitates the management of division maintained GIS datasets associated with the business systems in that particular division. It is, however, essential that all these GIS staff coordinate initiatives, lessons learned, and data management strategies. There could also be a situation envisioned where all Department GIS staff share the responsibility of maintaining the content of a possible GIS portal (see Goal 8).
- **Ensure that GIS skills and knowledge are present throughout the Department.** With the responsibility of maintaining GIS datasets falling on individual divisions, these divisions need staff with GIS skills. Some divisions, such as Planning, already have staff with these capabilities. Other divisions will have to train staff in (as a minimum) basic GIS concepts. Typically, a number of GIS staff at DOTs are engineers and scientists with multiple roles. Additionally, with GIS curriculum increasingly present in university engineering programs, most graduate or rotational engineers already possess GIS skills.
- **Encourage integration of UDOT DTS Staff in GIS initiatives across the Department.** The knowledge and experience of UDOT DTS staff in managing enterprise data systems and ensuring LRS integration is a vital component in a successful GIS integration strategy. Even though UDOT DTS staff are becoming increasingly familiar with GIS concepts, GIS is still not fully integrated in DTS day-to-day business functions. Since GIS technology over the years has become more compatible with and more reliant on enterprise database concepts, increased integration and collaboration between UDOT DTS and GIS staff and their associated job responsibilities will only be a matter of time. For example, the design and maintenance of a possible GIS portal (see Goal 8) should be a collaborative effort between Department DTS and GIS staff.
- **Coordinate larger application development initiatives across the Department.** Strategize up-front what would be the best use of staff resources in designing custom applications and how to maximize and utilize available talent and skills to provide the most “universal” benefit to the Department as a whole. Currently there are many GIS related application development initiatives at UDOT that do not always benefit from existing features, code, platforms, and lessons learned in general. This could save the Department significant time and money.
- **Establish a GIS technical support center.** It makes the most sense to have ETS work with customers across UDOT to help with GIS initiatives. If additional staff is needed, evaluate what staff can potentially transfer to ETS or use other

Department GIS staff and DTS staff as resources. The role of a technical support center could include facilitating data access; maintaining the content of a GIS portal; performing GIS analysis and application development upon request; technical support; and training. Maintaining key department datasets should not be a responsibility for ETS staff.

Goal 8 - Develop an online portal providing UDOT staff access to business data through GIS.

One of the keys to GIS success at the Department is establishing a central point of access for data and GIS tools. This is best accomplished by establishing a flexible web-based GIS portal (possibly in conjunction with some AGRC services).

Some key components should include:

- **Evaluating what type of web service is appropriate.** Options include:
    - Have the AGRC host the site.
    - Host the site from within UDOT, expanding UDOT's current GIS site (http://www.gis.udot.utah.gov/).
    - Intranet vs. Internet. Determine who needs access from where.
    - Establish password protected features where appropriate.
- **Providing staff with access to UDOT GIS data** which include, as a minimum, all master GIS datasets identified under Goal 1, and any other Department or non-Department datasets that are considered accurate, current, and that are properly maintained by those responsible for their maintenance. Data ideally should be available in three ways:
    - Through a direct (ArcSDE) link to the enterprise GIS system. In this case, users would add datasets to their desktop GIS application directly via the portal (and not actually "download" files containing the datasets), ensuring direct database connectivity.
    - Through downloading a shape file. In this case desired business data need to be queried from the enterprise system and are not directly linked with the enterprise database once they get downloaded. The advantage of this option is the portability of the dataset.
    - Through an online GIS display and analysis tool. In this case, the data can be added to a web based GIS interface for viewing and analysis. Online GIS viewers usually do not have the same capabilities for analysis compared to desktop GIS software packages, but the advantages are that users do not need any GIS software installed on their machines and data can be viewed and analyzed from anywhere.
- **Storing (or providing a link to) all current web-enabled GIS Sites within UDOT on the portal** making the site a one-stop shop for any GIS related efforts.
- **Investigating opportunities for user-driven growth** allowing people to exchange information and possibly add content.

Goal 9 - Establish an outreach strategy

Some observations regarding the Visioning Workshop are that people at UDOT either don't know much about GIS, but are interested, or display skepticism regarding the benefit of its application at UDOT, a perspective that also is often rooted in not being familiar with GIS. GIS is not a magic solution for everything, nor can it solve all the Department's problems. However, a successful integrated implementation of GIS' most important concept, the ability to link business data to geographic features for display and analysis, can make day-to-day business at UDOT easier and more efficient, likely saving the Department time and money. It is therefore recommended to establish an outreach strategy at various levels.

Possible outreach strategies could include:

- Making Department staff aware of how GIS can help them in their jobs; what data are available; the tools available for GIS display and analysis; and who to go to for help. This could be accomplished through a series of workshops and presentations at different divisions, groups, and regions.
- Informing Department staff of the proposed GIS strategy and access to Department business data and how a successful implementation is dependent on participation from every division, group, and region. This component of the outreach strategy could benefit from a "top down" endorsement beforehand.
- Incorporating ideas from people that have a genuine interest and desire to be more involved with GIS initiatives. Experience has shown that the best way to deal with passionate individuals with specific or different ideas regarding a proposed initiative is to integrate them in the team that is trying to find the solutions to achieve the set goals.
- When the proposed GIS portal goes "live," introduce this new tool through a Department-wide outreach initiative, e.g. a PR campaign, informing staff about capabilities and time-saving tools.

6.3 - Next Steps

For steps to be taken towards an optimized, integrated GIS strategy, it is vital to secure upper management support for the goals and recommendations presented in this plan. When the support for this plan is ensured and it is agreed upon that investing in and optimizing GIS at UDOT is a worthwhile effort from a business perspective, the necessary implementation and technology plans can be developed detailing funding and staffing needs. Related to these plans it is important to officially sanction a Department GIS committee and validate its mission and responsibilities.

Appendix A - Visioning Workshop Summary Report

Section 1 - Introduction

On January 31, 2008, a GIS Visioning Workshop was conducted for the Utah Department of Transportation. This workshop, facilitated by staff from Utah Department of Transportation (UDOT) and URS Corporation, was conducted as part of the overall effort of preparing a GIS Strategic Plan for UDOT. The workshop agenda consisted of a mix of presentations and interactive group exercises and is included as Attachment A. Fifty eight (58) people from UDOT attended this interactive afternoon session. Most major groups/divisions, and regions were represented and the day-to-day responsibility levels of the attendees varied from group/division management to design engineers, planners, field staff, and GIS specialists. In addition, three people from the State of Utah Automated Geographic Reference Center (AGRC) were invited to participate. The AGRC is currently in the process of establishing a strategic direction for GIS in the State of Utah in general and has been supporting UDOT through leveraging GIS data and technology. A full list of participants is included as Attachment B.

Section 2 - Workshop Purpose

The purpose of the workshop was to gather data to aid in the development of a strategic vision for GIS implementation at UDOT. Even though there is a lot of GIS activity at UDOT, this currently happens without any real sense of direction and purpose. As similar initiatives at other DOTs nationwide have shown, to allow for GIS to be successful as a technology, it needs to show that it directly benefits the department business processes. This workshop was intended to bring together UDOT staff from different groups, divisions, and regions to collect data regarding individual and Department-wide ideas, needs, opinions, and perceptions as they relate to GIS and how GIS can help make UDOT's business environment more efficient and effective.

Section 3 - Workshop Agenda

A. Presentations

In the first of the three presentations opening the workshop, Craig Hancock, Director of Technology Services at UDOT, provided a short framework for the workshop outlining the importance of a department-wide approach to GIS strategic planning; leveraging existing technology and solutions; and focusing on the business needs and obtaining management support. Secondly, Remmet deGroot from URS Corporation provided a quick introduction to GIS as a technology, and indicated that most DOTs across the country either completed or are in the process of preparing a GIS Strategic Plan and are dealing with similar issues and challenges. Finally, Bert Granberg from the AGRC provided a quick overview of statewide GIS initiatives and how cooperation between the AGRC and UDOT on GIS data and technology issues is beneficial to both agencies.

B. Interactive Group Exercises

Five interactive group exercises were conducted at the workshop. For the interactive sessions the attendees were divided into six groups with a facilitator assigned to each group. The group exercises included the following topics:

1) Interactive exercise on what GIS should and should not be.
2) Getting input on what GIS data people currently use and what data people would like to have access to.
3) Identifying what people perceive as the major challenges facing GIS implementation at UDOT.
4) Interactive survey of what people think should be the priority GIS application(s) for the Department.
5) Interactive discussion of the applicability and functions of a centralized GIS department.

Section 4 describes the results and preliminary conclusions of the group sessions and the survey.

Section 4 - Group Session Results

<u>Exercise 1</u>

Interactive exercise on what GIS should and should not be.

The results of this first exercise were grouped, summarized, and ranked based on the number of responses in each category from all six discussion groups. The top ten results for "GIS should" and "GIS should not" are listed below.

GIS Should:

1) ***Provide department wide (GIS) data integration.*** Responses included: be a department-wide standardized database; one system for all divisions, provide consistency between department data and databases; provide a wide variety of datasets supporting many department functions (specific needs were listed); unite department database and GIS systems, require data to be GIS compatible**.**
2) ***Provide more and easy availability and access to data to all divisions and users.*** Responses included: have data available on the fly; have a (categorized, searchable) list for available data (by division); provide contact info for (protected) datasets; have a zoom able map to see what data is available; provide quick tools to pdf and print maps of data.
3) ***Be more user friendly to non-expert.*** Responses included: GIS should be intuitive to use; colorful and fun to use; informative; use a lightweight application; easy to use without training; use widely available tools such

as Google Earth; not require a “heavy duty” computer; self explanatory; make complex data available to a non-technical audience; easy to learn.

4) ***Have accurate data that is properly maintained.*** Many responses stating exactly this.
5) ***Save money.*** Responses included: have tools for simplifying tasks; have a business need; generate meaningful analysis; support management level decisions; provide more efficient data management; cost effective; easy to maintain; be fast; provide effective internal and external communication; reliable; “make my life easier”.
6) ***Be web-delivered.*** Responses included: provide (public) web access; have a good interface; use web access since UDOT’s organization is decentralized; be web-delivered for in-the-field access.
7) ***Have proper QA/QC and metadata.*** Responses included: have a QA/QC protocol before releasing data to everyone; have portable and mobile QA/QC; have backups; have (good) metadata and metadata QA/QC, provide better insight on accuracy and purpose of each layer.
8) ***Have central oversight and coordination.*** Responses included: central oversight; central coordination; central storage to prevent duplication of data and effort; central coordination with regional control; be served through a GIS stand-alone division serving other divisions in UDOT.
9) ***Provide flexibility to customize for specific uses.*** Responses included: allow for customized applications for specific tasks; allow for each group to customize for their needs; be able to copy and modify for your use; allow for any user to be able to add their data to a map; provide for customizable analysis and map generation.
10) ***Have appropriate security.*** Responses included: provide security; be accessible to appropriate people; be accessible to everybody by level and password; provide different levels of security.

GIS Should Not:

1) ***Be complicated and hard to use.*** Responses included: require specialty software; require lots of technical knowledge; provide an information overload; require cumbersome imports and exports; require difficult data importing processes.
2) ***Be available to “a select few.”*** Responses included: restricted to certain users; have applications not available to everyone; limited to one section or division; be kept secret from other departments; be restricted by firewalls, user IDs, and passwords.
3) ***Be inaccurate.*** Responses included: have conflicting data; have outdated data; have duplicated data; have partial data; have incomplete data; have data entered into system without checks.

4) ***Inefficient; require excessive maintenance.*** Responses included: take a long time to implement and maintain; be expensive to maintain; create more work; be a hindrance to operations and/or project development.
5) ***Have central control or control in general.*** Responses included: central control; controlled; prescriptive; rely on one person to modify or create GIS datasets; require going through GIS expert to get what you want.
6) ***Be unsupported/underfunded.*** Responses included: be nickel and dimed; be anything else than a committed effort; be ignored; be abandoned; be forgotten; be a low-level priority on the side.
7) ***Try to solve every problem.*** Responses included: try to solve every problem; be the main user interface for my needs; limit data access to one tool.
8) ***Replace current applications.***
9) ***Limited to internal use only or done without AGRC or outside stakeholders.***
10) ***Rely on proprietary data or applications.***

Exercise 2

Getting input on what GIS data people currently use and what data people would like to have access to.

The results of this exercise show that people are using a variety of data that is either GIS compatible, GIS-enabled, or spatial in general. A representative summary is listed below. Almost all key datasets within UDOT are used in a GIS or spatial environment. However, many datasets show up in both the “currently using” and the “would like to have” categories (highlighted in bold in the below table), which indicates that these datasets are likely not standardized and not readily available across departments. It is also possible that the quality, extent, or resolution of the data might be adequate for one purpose/division, but not for another. Finally, some of the requested datasets are readily available from the AGRC. In this case, people might not know what is available outside UDOT.

GIS Data People Are Using	GIS Data People Would Like
Signals and Lighting Data	ROW Data
Aerial Photography (NAIP-AGRC)	**Aerial Photography**
Google Earth (other online)	**CADD Data/As-Built Data**
BLM Data	**Pavement Condition Data**
PLSS (Township, Range, Section)	**Maintenance (Shed) Data**
CADD Data	**Permit Data**
LRS/Roadway Data/Road Classif.	Plan for every section
Pavement Condition Data	Long Range Plan
Permit Data	**Traffic/Accident Data**
Traffic/Accident Data	**Bridge (Inventory) Data**
Bridge (Inventory) Data	**Property/Land Ownership**
Maintenance (Shed) Data	**AADT**
Rest Areas	**Attributed Roadway Inventory**
Hydrologic/Hydraulic Data	**Hydrologic/Hydraulic Data**
Environmental Data	511 Info
AADT	Utilities
Fiber Data	**T&E Species**
Property/Land Ownership	Bus Routes
USGS Quadrangles	Construction Segments
AGRC Archaeological Database	Soil Bore Logs
UDOT Airport Layouts	Road Closures
Wildlife Hits/Accidents	Local & County Planned Projects
T&E Species	Population Density
Research Experimental Failure	Materials Database
Construction/Commuter Link	Funding Tied to Regions
MMQA	Document Management
Surplus Property	Asset Management
Device Placement (ATMS)	**Environmental Data**
Signs	Weather Tracking
Outdoor Advertising Data	Avalanche Data
State Highway Map	Real Time Plow Tracking

Exercise 3

What do people perceive as the major challenge(s) facing GIS implementation at UDOT?

The results of this exercise were grouped, summarized, and ranked based on the number of responses in each category from all six discussion groups. The top 15 results are listed below.

1) ***No easily defined benefits.*** Responses included: not obvious why GIS is needed; absence of senior support; no overall set of goals; lack of governance; inability to clearly define an end result that can be promoted for funds and resources; no champion; not easily identified benefits; high, easily identified costs to implement and maintain with no easily identified benefits; lack of a long term commitment.
2) ***Lack of training.*** Responses included: not knowing how to use tabular data in GIS; knowledge of software; don't know GIS potential; too complex for casual user; software changes too fast; not user friendly; to steep of a learning curve.
3) ***Data maintenance issues.*** Responses included: keeping data current; no duplication; keeping data up-to-date; data completeness; too much data to maintain; skepticism towards feasibility of maintaining all data; data collection limitations.
4) ***Lack of funding.***
5) ***Lack of dedicated FTEs / technical support.*** Responses included: no dedicated FTEs; no help desk; no technical support; too dependent on Chris Glazier; need better administration and coordination.
6) ***Data integration issues.*** Responses included: database integration issues; inconsistent data; interfacing with Oracle and other existing information systems; department data coordination; incompatibility with existing systems; reference system incompatibilities; data formats often application specific.
7) ***Lack of outreach to UDOT staff.*** Responses included: don't know what data is available; don't know where data is; idea doesn't get "sold" to users; no vision and steering; no one-stop shop to see what data is available.
8) ***Lack of data standards and documentation.*** Responses included: no documentation on data and data management processes; no good metadata; no information on data accuracy or what the data was intended for.
9) ***Data ownership / responsibility issues.*** Responses include: who does what?; no defined or consistent definition of roles and responsibilities;

central or local control; who can change or correct data; “do we manage a key roadway attribute that is most relevant to our division, or do we have to go through a central ‘approval’ process.”

10) ***Software / hardware access.*** Responses included: don’t have access to software; don’t have license; my computer is not powerful enough; my internet connection is too slow.

11) ***Data access issues.*** Responses included: too many hoops to jump through to get the data you need; inefficient; data I want is not available; no “finalized” dataset for people to use across the department; data is always “in the works” and tied to a specific application or data collection effort.

12) ***Data security concerns.*** Responses included: privacy concerns; liability concerns; data could get in the hands of those that could use it against us; trusting outside resources or partners.

13) ***Data quality concerns.*** Responses included: lack of QA/QC, who is responsible for QA/QC; has the data been checked.

14) ***Time consuming implementation.*** Responses included: requires rewriting of policy and procedures; getting database and GIS implementation or setup in a timely manner; takes more time to set up than it takes me to do the job.

15) ***Data storage concerns.*** Responses included: where do we store the data; what do we co-locate with the AGRC; need more coordination with outside state and federal agencies and local entities.

Exercise 4

What should be the priority GIS application for the department?

The results of this exercise were grouped, summarized, and ranked based on the number of responses in each category from all six discussion groups. The top ten applications are listed below.

Rank	Application
1	**LRS application.** Tracking changes to LRS; geocoding from LRS to GIS
2	**Feature inventory application.**
3	**Pavement management application.** Management and decision tool
4	**Base map service application.** Ability to overlay and post (GPS) user data.
5	**Environmental resources portal.**
6	**ROW mapping application.**
7	**Application to store and retrieve project archive information.**
8	**Traffic application.** Real time traffic, safety, AADT, vehicle class, future planning
9	**STIP/Long Range Plan application.** Past and future projects, PM project tool
10	**Crash data application.**

Exercise 5

What is the applicability and function(s) of a centralized GIS department?

The summarized results of this exercise were divided into three categories: functions, advantages, and disadvantages.

Functions
Establish standards and consistency in the system Provide technical expertise / help desk Assist end users with data input and data access Assist with procedures and data collection policies Manage central data Conduct GIS application development or co-manage development efforts Provide training Pool funds Establish senior management support / possibly report to deputy director directly Establish coordination between complex and regions / facilitate data sharing Possibly have staff sitting in regions reporting to central GIS department Coordination with other entities both internal and external for data acquisition Development of web services Provide support to groups that don’t have resources (similar to CAD support)

Advantages
Data standardization
Data development and management
Training
Continuity of knowledge – both technical and business
Improve accessibility of data
Application development
Provide champion for GIS
Promote efficiencies for UDOT GIS solutions
Facilitates organizational structures within UDOT that support GIS
Manage licenses
Describe data sets
Data integrity across systems
Identify data, make available to UDOT and public; provide outreach
Manage current and future applications
Guide and coordinate GIS developments
Implement Strategic Plan

Disadvantages
Potential conflicts over priorities with limited people and funds
Creates more overhead: “GIS governing body”
Could slow down software development
Creates distance/disconnect between GIS development and customers
Does not work if it’s not appropriately staffed
GIS is not a “silver bullet”; won’t solve all of our problems
Quality control of source data should not be performed centrally
Users need to be able to develop application
GIS experts should be in the regions
Overwhelming workload for central GIS staff
Lack of resources
Too many hats
Lack of flexibility
Expertise shouldn’t be in one spot
Needs increased customer focus if this department is the go-to option
Need to be able to get my stuff fast if this is the go-to option

ATTACHMENT A: Workshop Agenda

GIS Visioning Workshop
UDOT's GIS Strategic Plan

► agenda

► **DATE:** ***January 31, 2008*** ► **TIME:** ***1:00 p.m. – 5:00 p.m.***

► **PLACE:** **SLCC - Larry H. Miller Campus – KGMC Building**

1:00 – 1:15: Welcome – Introductions………………………….…..... *Remmet deGroot (URS Corp.)*

1:15 – 1:30: UDOT GIS Strategic Plan – Setting the Framework………*Craig Hancock (UDOT)*

1:30 – 1:45: Geographic Information Systems and DOTs…....…..*Remmet deGroot (URS Corp.)*

1:45 – 2:00: GIS in Utah – AGRC Presentation………………………… *Bert Granberg (AGRC)*

2:00 – 2:15: Break

2:15 – 3:25: Roundtable Discussions (Exercises 1, 2, and 3)

3:25 – 3:40: Break

3:40 – 4:45: Roundtable Discussions (Exercises 4 and 5)

4:45 – 5:00: Wrap-up – Next Steps……….. *Craig Hancock (UDOT)*

ATTACHMENT B: List of Participants

	Attendee	Department
1	Tracy Conti	UDOT – Operations / Director
2	Craig Ide	UDOT – Operations / Aeronautics
3	Lloyd Neeley	UDOT – Operations / Maintenance
4	Tim Ularich	UDOT – Operations / Maintenance
5	W. Scott Jones	UDOT – Operations / Traffic & Safety
6	Regis Chen	UDOT – Operations / Traffic & Safety
7	Wes Starkenburg	UDOT – Operations / Traffic & Safety
8	Larry Montoya	UDOT – Operations / Traffic & Safety
9	Raymond Earl	UDOT – Project Development / Structures
10	Betsy Skinner	UDOT – Project Development / Environmental
11	Kevin Kilpatrick	UDOT – Project Development / Environmental
12	Chris Glazier	UDOT – Project Development / ETS
13	Derek Peterson	UDOT – Project Development / ETS
14	Gary Williams	UDOT – Project Development / ETS
15	Craig Hancock	UDOT – Project Development / ETS Director
16	Leslie Heppler	UDOT – Project Development / Geotechnical
17	Keith Brown	UDOT – Project Development / Geotechnical
18	Jim Baird	UDOT – Project Development / Hydraulics
19	Fred Doehring	UDOT – Project Development / PM Eng
23	Shana Lindsey	UDOT – Project Development / Research-Bridge – Director
22	Michael Fazio	UDOT – Project Development / Research Deputy Director
20	Ken Berg	UDOT – Project Development / Research
21	Doug Anderson	UDOT – Project Development / Research
25	Karen Stein	UDOT – Project Development / ROW Deputy Director
24	Wendell Hathaway	UDOT – Project Development / ROW
26	John Thomas	UDOT – SPP – Transportation Planning Director
27	Tim Rose	UDOT – SPP – Asset Mgmt Director
28	Peter Jager	UDOT – SPP – Engineer for Planning Statistics
29	Christopher Meredith	UDOT – SPP – Planning – GIS
30	Scott Nay	UDOT – SPP – Road Inventory
31	Lee Theobald	UDOT – SPP – Traffic Monit. Program Supervisor
32	Jeff Ericson	UDOT – SPP
33	Tony Lau	UDOT – Engineering Services
34	Troy Hyer	UDOT – Traffic Operations Center
35	Lynne Yocom	UDOT – Traffic Operations Center / ITS
36	Jeff Erdman	UDOT – Region 1 – Hydraulics
37	Marjorie Rasmussen	UDOT – Region 1 – PM

	Attendee	Department
38	Scott Nussbaum	UDOT – Region 1 – Region Materials Engineer
39	Paul Egbert	UDOT – Region 1 – Support Services Engineer
40	Kelli Bacon	UDOT – Region 2
41	Ken Wharff	UDOT – Region 2
42	Richard Manser	UDOT – Region 2 – Rail/Transit Eng. Liaison
43	Jerry Timmins	UDOT – Region 2 – ROW-Survey
44	Shawn Debenham	UDOT - Region 2 - ROW-Survey
45	Brent Schvaneveldt	UDOT - Region 3
46	Rod Hess	UDOT - Region 3
47	Justin Schellenberg	UDOT - Region 3
48	Marco Palacios	UDOT - Region 3 - Field Engineer
49	Richard Crosland	UDOT - Region 3 Preconstruction
50	Jim McConnell	UDOT - Region 4 Cedar District
51	Laurel Glidden	UDOT - Region 4 Cedar District
52	Jim Chandler	UDOT - Region 4 Price District
53	Dave Burton	DTS - Info System Services - Manager
54	Ruben Schoenefeld	DTS - Info System Services
55	Jake Payne	DTS - Info System Services
56	Dan Paske	DTS - Info System Services
57	Monty King	DTS - Info System Services
58	Robert Higgins	DTS - Info System Services
59	Dennis Goreham	Department of Technology Services (AGRC)
60	Bert Granberg	Department of Technology Services (AGRC)
61	Jeannie Watanabe	Department of Technology Services (AGRC)
62	Remmet deGroot	URS Corp. - PM - Sr. GIS Consultant
63	Deborah Jensen	URS Corp. - GIS Specialist
64	Rachel McQuillen	URS Corp. - Sr. Engineer / Manager
65	Troy Spjute	URS Corp. - GIS Developer/Programmer